A Language Use Perspective on the Design of Human-Computer Interaction

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Motivating question

How can user interfaces better support users?

Observations

- People use language (in all senses where meaning and understanding are needed) to do things with each other, e.g., to collaborate
- People's language use skills are their most fundamental resource in all interaction contexts involving meaning and understanding
- Although people interact with computers to do things, people are also the authors of human-computer interaction designs

Implications

- The design of human-computer interaction is a representation problem that involves the designer's meaning and the user's understanding
- Accommodating the principles of how people use language is relevant as a framework for the design of human-computer interaction

What is language use?

Language use

- allows people to carry out joint activities
- is a collaborative form of joint action built on individual actions
- always involves at least one person's meaning and another's understanding
- depends on representation, i.e, the use of signs and symbols as signals
- is a cognitive science and a social science
- is not the study of linguistics

Principles of language use

- Language is used to carry out joint activities
- Language use is defined by joint actions that arise from the coordination of cognitive, physical, and perceptual actions people (e.g., speaker and addressee) carry out as individuals
- A joint activity's setting determines how these joint actions are coordinated and what skills are needed
- Face-to-face settings are the most basic, written settings are the most demanding
- Meaning and understanding in joint actions requires common ground

What is common ground?

Common ground

- is *knowledge people take to be held in common* on the *basis of shared information*

- People try to justify and use common ground by presenting what they believe are shared bases for it
- Signals in use among people (e.g., words and gestures) are examples of such shared bases of information
- Common ground presupposes certain cognitive processes and is built up moment-by-moment over a lifetime of joint activities and experience

Three parts of common ground in joint activities:

- knowledge initially taken to be held in common
- knowledge of the joint activity's current state
- knowledge of what has openly taken place so far

More principles of language use

- People expect each other to accrue and use knowledge and information corresponding to common ground
- Each joint action involving meaning and understanding is a coordination problem people must try to solve together
- When people pose coordination problems to each other, they usually have specific solutions in mind and can be expected to present *the most salient and sufficient bases with respect to their common ground* as coordination devices for indicating these solutions
- External representations and conventions are excellent sources of coordination devices
- Language use frequently involves more than one conceptual layer of activity

Language use in human-computer interaction

Claim: human-computer interaction is a *genuine instance of language use*

- It is a layered joint activity (doing a computational task) in which all principles of language use apply, whose primary participants are the designer and the user in these roles
- The joint actions that make up this joint activity arise from the coordination of individual cognitive, physical, and perceptual actions
- These joint actions depend on common ground and always involve the designer's meaning and the user's understanding
- It takes place in a particular type of written setting whose scene and medium are a pre-planned, interactive computational presentation

Comparing written settings

Human-computer interaction differs from a conventional written setting:

- Second layer of action takes place in a face-to-face setting
- Presentation is nonlinear and deliberately opportunistic
- Common ground is built differently in both first and second layers
- External representation of joint activity is dynamic, partly evanescent

	Book	**Human-computer interaction**
Joint activity	Relating subject matter of book	Relating and doing computational task
Setting	Written in all layers	Written in 1st layer, face-to-face in 2nd
Presentation	Linear, static	Nonlinear, opportunistic
Participants	Writer, reader; possibly others in other layers	Designer, user; computer in 2nd layer
First layer	Writer, reader as themselves	Designer, user as themselves
Second layer	Writer, reader immersed in subject matter	User and computer carrying out task
Common ground - initial	Conventional literacy, introduction	Computer literacy, tutorial
Common ground - state	Corresponds to bookmark	May correspond to state of display
Common ground - events	Corresponds to previous portion of book	Corresponds to interaction history
Meaning & understanding	Writer poses coordination problems	Designer poses coordination problems
Coordination devices	Elements on page	Elements and behavior of display
External representation	Printed matter	Dynamic, partly evanescent display
Conventions	Written language, organization	Actions, display elements, input devices

Layers in human-computer interaction

Human-computer interaction has two principal layers of activity

First layer:

- Designer and user carry out a joint activity whose purpose is to carry out a computational task *as themselves* in these roles
- Takes place in a *written setting*

Second layer:

- User interacts with the computer to carry out the same joint activity *as if the computer were the user's counterpart*
- Takes place in a *face-to-face setting*

- Each layer makes different demands of the user's language use skills

Presentation properties of human-computer interaction

The presentation:

- serves as an external representation of the joint activity
- poses a fixed set of coordination problems (joint actions) whose solution depends on the user's participation (i.e., comprehension and physical interaction)
- uses a language of coordination devices made up of a variety of linguistic and nonlinguistic signals, including elements of natural language, visual artifacts, and behaviors (i.e., actions and procedures)
- depends on many elements of the presentation language to be construed as conventions

Note: users depend on the designer, in posing coordination problems for carrying out the joint activity, to honor their expectations of salience, sufficiency, and solvability

Additional presentation properties of human-computer interaction

Presentation is nonlinear and opportunistic:

- User has opportunistic control of joint activity
- Opportunistic design gives direct, nonlinear access to starting points for carrying out goals and subgoals
- Elements of the joint activity anticipated by the design are presented as planned, linear interaction sequences
- Branching afforded by design inherently leads to contingent paths among planned interaction sequences

Presentation's external representation of the joint activity:

- Serves in part as a manipulable model of the joint activity, but does not always indicate its state
- Is accessible to both the user and the system but is mostly unused by the system to justify common ground
- Actions in the external representation are often evanescent

Knowledge people accumulate about interactions

Claim: In any interactive activity, the knowledge people accumulate and are able to justify corresponds structurally to the three parts of common ground:

- knowledge initially held about the activity
- knowledge of the activity's current state
- Knowledge of what has taken place in the activity

Knowledge of an activity:

- is common ground when the interaction takes place between people and shared informational bases exist to justify it as common ground
- is only an individual's conception of the activity when the interaction takes place with elements of the environment that accrue no such knowledge
- is part common ground and part individual conception in human-computer interaction

Common ground in the *first layer* of human-computer interaction

In a nonlinear presentation:

- Both the designer and the user strive to find and build common ground, but…
- The designer's control over the process of building a complete body of common ground with the user in the planned manner of a linear presentation is sacrificed
- The user's common ground with the designer builds contingently on the basis of
  - Opportunistically becoming familiar with the presentation language
  - Opportunistically solving coordination problems posed in the interaction design
- Over time, the user develops a sense of where common ground is missing and will often look for it unless the effort proves to be too expensive

Common ground in the *second layer* of human-computer interaction

When the user engages the computer through a software user interface:

- The interaction is designed to resemble a joint activity in a face-to-face setting
- The user actively keeps track of contingent interaction knowledge corresponding to three parts of common ground as well as informational bases to justify it
- At most, software keeps track of some of the same knowledge and shares informational bases in limited, ad hoc ways, such as undo mechanisms and other kinds of interaction histories
- Contingent interaction knowledge the software fails to be able to justify and use cannot be construed as common ground in the setting nor the layer
- User's face-to-face language use skills go largely unused

Improving language use in human-computer interaction

Claim: when the normal function of common ground in a language use setting is impaired, people are forced to work harder cognitively to accomplish their goals

Since opportunistic interaction inherently builds incomplete common ground in the *first layer* of an interaction design,

- users need inexpensive access to missing knowledge when they encounter discrepancies in their common ground
- users need inexpensive ways to off load and/or confirm their understanding

Reliable use of additional contingent interaction knowledge by the user interface in the *second layer* of human-computer interaction can give users opportunities to:

- make increased use of their face-to-face language use skills
- make more efficient use of their cognitive resources

Complementary approaches to language use in human-computer interaction

Noncomputational approach

- Common ground between user and designer in their roles as participants in the joint activity of doing a computational task is a sine qua non for usability
- This is essentially user-centered design viewed from a language use perspective
- Empowers user; applies mostly to first layer concerns

Computational approach

- Many, if not most, aspects of reasoning about common ground are computationally challenging
- Ultimately, this is a design problem for artificial intelligence techniques
- Potential for sharing user's cognitive load and capitalizing on user's language use skills in revisions and repairs

Noncomputational approach

Goal: to improve usability in fixed interaction designs through the application of principles of language use

As part of the usability engineering process,

- evaluate the presentation language as a set of shared informational bases for knowledge about the design that should be taken as common ground for the joint activity:
  - Look for shared bases that are ambiguous, obscure, or indicate knowledge that should not be common ground
  - Evaluate use of convention and novelty
- evaluate the interaction design as a set of coordination problems and look for violations of language use principles:
  - Are expectations of salience, sufficiency, and solvability met?
  - Do interaction results confirm user's intentions?
  - Can misunderstandings arise due to timing or coordination?

More on Noncomputational Approach

Provide enhanced, interactively inexpensive ways for users to find and reinforce common ground on their own such as:

- point of use reference and annotation mechanisms that take user to relevant entries in glossaries, procedural descriptions and limitations, tutorials, personal notes, etc.
  - Dowdy but fertile area for additional interaction design research
  - Minimize cost of interruption in terms of leaving, using, and returning to reference, and returning to point of use
- full interaction history mechanisms that can be used and reviewed
  - Interaction histories correspond to third part of common ground in joint activities
  - Interaction design and use issues similar to those above apply

Computational approach

Goal: to share user's cognitive load and promote user's language use skills in the face-to-face setting (second layer) of human-computer interaction

Note that many behaviors in user interface can be confused with maintenance of common ground by computer

- Reactive behaviors (e.g., passive interactions with cursor)
- Alerting and corrective behaviors (e.g., spelling, grammar)
- History mechanisms (e.g., undo, recent documents, etc.)

Functional common ground between the user and the computer can only arise when the computer:

- maintains a system-side representation of the three parts of common ground in user interactions
- can justify this knowledge on the basis of shared information
- can use this knowledge to advance the joint activity

More on computational approach

Challenges and issues...

- Significant computational goals:
  - Representing and verifying what the user does and does not know about the joint activity
  - Perceiving and solving coordination problems posed by user
  - Identifying and using conventions
- Issues:
  - Designing face-to-face interactions about interactions to capitalize on user's language use skills
  - What knowledge is appropriate for common ground? (reasoning about content vs. reasoning about functionality)
  - Shared knowledge the system can justify can also be used as a basis for initiative - when is initiative appropriate?

Relevant work at NRL

- Collaborative Engineering Environments (ONR)
  - Design studies (with H. Ng, NRL)
  - WARCON CEE IPT member (ONR)
  - Language Use Principles for Developing Collaborative Environments (Brock, 2000, unpublished paper)
- Task model tracing (NRL, ONR)
  - ACT-R model of resource allocation task used to trace user interactions and compute common ground
  - A Language Use Approach to Human-Computer Interaction (Brock, 2001)
- Alerting and Interruption (ONR)
  - Multimodal interface studies (with J. Ballas, NRL)
  - Interruption studies (with G. Trafton, NRL)

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